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EXPEDITED PROCEDURE
EXAMINING GROUP 2516

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5/20/97

35.G 1008 CIP1\C1

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:)
(Continuation of 08/389,579, :
filed 02/15/95))
NAOKI NISHIMURA)
Appln. No.: Not yet assigned)
Filed: May 13, 1997)
For: MAGNETOOPTICAL RECORDING)
MEDIUM AND METHOD FOR :
REPRODUCING INFORMATION)
FROM A MAGNETOOPTICAL :
RECORDING MEDIUM HAVING)
THREE LAYERS :

Examiner: Ali Meyzari

Group Art Unit: 2516

May 13, 1997

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MAY 19 1997

GROUP 2500

Assistant Commissioner for Patents
Box AF
Washington, D.C. 20231

REQUEST FOR ACKNOWLEDGMENT
OF RECEIPT OF SWORN TRANSLATION AND
WITHDRAWAL OF THE HIROKANE, ET AL. PATENT AS A REFERENCE

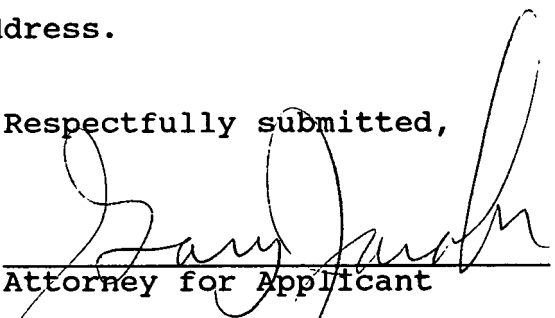
Sir:

Applicant requests acknowledgement of receipt of the
sworn translation of Japanese Priority Application No.
5-038138 on April 17, 1997 and withdrawal of the Hirokane, et
al. patent as a reference.

For the Examiner's convenience, attached is a copy of the sworn translation, the Submission of Sworn English Translation, and the stamped postcard receipt, indicating the filing of the translation on April 17, 1997.

Applicant's undersigned attorney may be reached in our Washington, D.C. office by telephone at (202) 347-8100. All correspondence should continue to be directed to our below listed address.

Respectfully submitted,



Attorney for Applicant

Registration No. 28,861

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F505\W136433\GMJ\efc

Assistant Commissioner for Patents
Washington, D.C. 20231

Date 4 / 17 / 97
Mo. Day Yr.

Atty. Docket 35.61008

Application No. 08/389,579
CIP1

Sir:

Kindly acknowledge receipt of the accompanying:

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- ☐ Response to Official Action. _____
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- ☐ Information Disclosure Statement, PTO-1449 and _____ documents
- ☐ Claim for priority and certified copies of _____ priority applications
- ☐ Issue fee transmittal and Check for \$ _____

☒ Other (specify) Submission of Super English Translation
and English Translation of App. No. 9-038138
by placing your receiving date stamp hereon and returning to deliver.

Atty. GMI/efc

Due Date N / D / D
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RESPONSE UNDER 37 C.F.R. § 1.116
EXPEDITED PROCEDURE
EXAMINING GROUP 2516

35.G 1008 CIP1

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:)
NAOKI NISHIMURA) Examiner: Ali Neyzari
Appln. No.: 08/389,579) Group Art Unit: 2516
Filed: February 15, 1995)
For: MAGNETOOPTICAL RECORDING) April 17, 1997
MEDIUM AND METHOD FOR)
REPRODUCING INFORMATION)
FROM A MAGNETOOPTICAL)
RECORDING MEDIUM HAVING)
THREE LAYERS)
(As Amended))

The Assistant Commissioner For Patents
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Washington, D.C. 20231

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GROUP 2500

SUBMISSION OF SWORN ENGLISH TRANSLATION

Sir:

Attached hereto is a sworn English translation of one of the priority documents in the subject application, namely Japanese Patent Application No. 5-038138, filed on February 26, 1993.

Since the filing date of this priority document predates the filing date of the patent to Hirokane, et al., the Hirokane, et al. patent is not a reference against the

present application. Accordingly, the rejection of the claims over the Hirokane, et al. patent should be withdrawn.

Applicant's undersigned attorney may be reached in our Washington, D.C. office by telephone at (202) 347-8100. All correspondence should continue to be directed to our below-listed address.

Respectfully submitted,

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D E C L A R A T I O N

I, KAZUO KATO, a subject of Japan residing at
No.10-602 Ohtsugaoka 3-17, Shonan-machi, Higashikatsushika-gun,
Chiba 277, Japan, solemnly and sincerely declare:

That I have thorough knowledge of Japanese and English
languages: and

That the attached pages contain a correct translation
into English of the specification of the following Japanese
Patent Application:

APPLICATION NUMBER

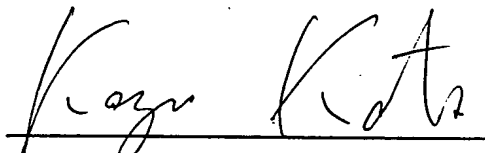
5-038138

DATE OF APPLICATION

February 26, 1993

I hereby declare that all statements made herein
of my own knowledge are true, and that all statements made
on information and belief are believed to be true; and further,
that these statements are made with the knowledge that willful
false statements and the like so made, are punishable by fine
or imprisonment, or both, under Section 1001, Title 18 of the United
States Code, and that such willful false statements may jeopardize
the validity of the application or any patent issuing thereon.

Signed this 27th day of March, 1997

A handwritten signature in cursive script, appearing to read 'Kazu Kato', is written over a horizontal line.

KAZUO KATO

Name of Document: PATENT APPLICATION

Reference Number: 2467028

Filing Date: February 26, 1993

Address: Director-General of the Patent Office
Mr. WATARU ASOH

International Classification:

G112B 7/10

Title of the Invention:

A magneto-optical recording medium
and information reproducing methods
by using the medium

Number of the Claims: 3

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Indications of Fee:

Kind of Payment: Advanced Payment

Registered Number of Advanced Payment: 011224

Amount of Payment: ¥ 14000

List of Filed Articles:

Specification one copy

Drawings one copy

Abstract one copy

Number of General Power of Attorney: 9003707

Necessity of Proof: YES

NAME OF DOCUMENT

Specification

TITLE OF THE INVENTION

A Magneto-optical Recording Medium
And Information Reproducing Methods
Using The Recording Medium

CLAIMS

1. A magneto-optical recording medium comprising:

a first magnetic layer being an in-plane magnetization film at room temperature and raised temperatures, and changed to a perpendicular magnetization film at intermediate temperatures therebetween; and

a second magnetic layer composed of a perpendicular magnetization film.

2. A magneto-optical recording medium according to claim 1,

further comprising a third magnetic layer being interposed between said first magnetic layer and said second layer

and having Curie temperature lower than Curie temperatures of said first and second magnetic layers.

3. An information reproducing method using a magneto-optical recording medium, wherein

said magneto-optical recording medium comprises:

a first magnetic layer being a perpendicular magnetization

film at room temperature and changed to an in-plane magnetization film at raised temperatures; and

a second magnetic layer composed of a perpendicular magnetization film,

said method comprising the steps of:

changing said first magnetic layer to a perpendicular magnetization film, in its region within a light spot projection portion, by projecting a light spot onto said first magnetic layer;

aligning a magnetization direction of said region in a stable direction with respect to a magnetization direction based upon information recorded on said second magnetic layer; and

reproducing said information by utilizing magnetooptic effect of reflective light of said light spot.

DETAILED DESCRIPTION OF THE INVENTION

Field of the Industrial Use

The present invention relates to a magnetooptical recording medium for information recording and reproduction by irradiation with a laser beam by utilizing magneto-optic effect, and information reproducing methods using the recording medium.

Prior Art

A magnetooptical recording medium has become a subject of attention in the field of a rewritable and high recording density

recording method. In such a recording medium, information is recorded on the recording medium by forming a magnetic domain on a magnetic film in the medium by means of thermal energy of a laser beam from a semiconductor laser, and the information is read out from the medium, by utilizing magneto-optic effect. In recent years, the above noted trend is based on need for a larger amount of recording capacity, which can be attained by higher density of such a recording medium.

Incidentally, linear density of an optical disc, such as a magneto-optical recording medium, is largely dependent upon the wavelength of a laser beam and the numerical aperture of an objective lens used in an optical system for reproducing information.

That is, when the wavelength λ of a laser beam used in a reproducing optical system and the numerical aperture NA are determined, when the numerical aperture NA are determined, a bit periodicity, which is the limit of detection, is defined as $\lambda/2NA$.

Track density, however, is chiefly limited by crosstalk. The crosstalk is determined mainly by the laser beam distribution on a medium surface (profile) and is expressed as a function of $\lambda/2N$ similar to the bit periodicity mentioned above.

Thus, the wavelength of laser beam must be shortened and the numerical aperture of objective must be enlarged in order to increase recording density of the conventional optical disc.

However, there are limitations to improvement of the wavelength of a laser light and the numerical aperture of an objective. Techniques, then, have been developed, which improve the structure of a recording medium and a method of reading out data bits so that the linear recording density can be improved.

Japanese Patent Laid-Open No. Heisei 3-93058, for example, discloses a method which is performed by using a recording medium which is composed of a readout layer and a recording layer, orienting the direction of magnetization in the readout layer in a single direction, prior to signal reproduction, and thereafter, transferring signal held in the recording layer to the readout layer. Thus, it becomes possible to reduce interference between codes at the time of signal reproduction and to reproduce signal recorded at periodicity below the limit of light diffraction so that linear recording density can be improved.

Problems to be Solved by The Present Invention

However, the magneto-optical reproducing method of Japanese Patent Laid-open No. 3-93058 requires a step of aligning the magnetization direction of the readout layer in a single direction before laser beam projection. Thus, it is necessary to add a magnet for initializing the readout layer to a conventional apparatus. Because of such addition, problems have arisen such as more complicated structure of a magneto-optical recording apparatus, difficulty of down-sizing, and higher cost of an apparatus.

Means for Solving The Problems and function

It is an object of the present invention to provide a magneto-optical recording medium and information reproducing methods using the medium, which has simple configuration and can reproduce a signal of high S/N ratio whose periodicity is below the limit of light

diffraction.

The object is attained by a magneto-optical recording medium which comprises a first magnetic layer being an in-plane magnetization film at room temperature and raised temperatures and changed to a perpendicular magnetization film at intermediate temperatures therebetween, and a second magnetic layer composed of a perpendicular magnetization film.

Further, the object is attained by an information reproducing method using a magneto-optical recording medium which comprises a first magnetic layer being a perpendicular magnetization film at room temperature and changed to an in-plane magnetization film at raised temperatures, and a second magnetic layer composed of a perpendicular magnetization film. The method comprises a step of changing said first magnetic layer to a perpendicular magnetization film, in a region within a light spot projection portion, by projecting a light spot onto said first magnetic layer, a step of aligning a magnetization direction of said region in a stable direction with respect to a magnetization direction based upon information recorded on said second magnetic layer, and a step of reproducing said information by utilizing magneto-optic effect of reflective light of said light spot.

Embodiments

A magneto-optical recording medium and information reproducing methods using the medium, according to the present invention, will be described in detail with reference to figures.

A magneto-optical recording medium of the present invention

is composed of at least two layers: a readout layer which remains an in-plane magnetization film at room temperature and is changed to a perpendicular magnetization film when the temperature is raised, and returns to an in-plane magnetization film or its magnetization disappears, when the temperature is further raised; and a recording layer which is a perpendicular magnetization film at both room temperature and raised temperatures.

The readout layer is desirably composed of, for example, rare-earth and iron group metal amorphous alloy, such as GdCo, GdFeCo, GdTbFeCo, GdDyFeCo, NdGdFeCo, etc. Material is preferable which has small magnetic anisotropy or compensation temperature between room temperature and Curie temperature.

The recording layer is desirably composed of material having large perpendicular magnetic anisotropy and able to hold magnetized state stably, for example, rare-earth and iron group amorphous alloy, such as TbFeCo, DyFeCo, TbDyFeCo, etc.; or garnet; or platinum group and iron group periodical structure layer, such as Pt/Co and Pd/Co; platinum group and iron group alloy, such as PtCo and PdCo. Elements for improving corrosion resistance, such as Cr, Al, Ti, Pt, Nb and the like, may be added to magnetic layers, such as the readout layer, recording layer and so forth, respectively.

Further, dielectrics, such as SiNx, AlNx, TaOx, SiOx, etc., may be formed in addition to the readout and recording layers for improving interference effect. Al, AlTa, AlTi, AlCr, Cu, etc. may be formed for controlling thermal conductivity.

Still further, an intermediate layer for adjusting exchange-coupling force or magnetostatic coupling force, or an auxiliary layer

for assistance of recording or reproducing, may be formed. A protecting film may be used as protective coating which is composed of the above-mentioned dielectric or high polymer resin, furthermore.

The following description deals with an information reproducing method according to the present invention.

Referring to Fig. 1, data signal is recorded on the recording layer of the magneto-optical recording medium according to the present invention. One way of recording data signals is to modulate an external magnetic field while projecting a laser beam powerful enough to raise the temperature of the recording layer equal to or more than Curie temperature. Another way is to modulate laser power while applying a magnetic field in a recording direction, after eliminating data. Still another way is to modulate laser power while applying an external magnetic field.

In recording the data, the intensity of the laser beam is determined so that the temperature of a predetermined region within the beam spot can be raised near to Curie temperature, considering the linear velocity of the recording medium. Such determination on the intensity enables a recorded magnetic domain, which is less than the diameter of the laser beam spot, to be formed, and thus it is possible to record a signal having periodicity less than the limit of light diffraction.

When reproducing the data signal, a readout laser beam is projected onto the recording medium. At this time, the temperature in the region irradiated with the beam rises. Since the recording medium moves at a constant speed, the temperature distribution on the recording medium has a shape extending along the moving direction, as shown in

Fig. 4 or Fig. 5. In the temperature distribution, a part of the irradiated portion within the beam spot is a high-temperature area.

Regarding a magnetic thin film composed of a single layer, when saturation magnetization is named M_s and a perpendicular magnetic anisotropy constant is named K_u , an effective perpendicular magnetic anisotropy constant named K_{\perp} is defined in the following equation:

$$K_{\perp} = K_u - 2\pi M_s^2$$

It is known that a chief magnetization direction is determined by the effective perpendicular magnetic anisotropy constant K_{\perp} . A perpendicular magnetization film appears when K_{\perp} is positive and an in-plane magnetization film appears when K_{\perp} is negative.

Here, $2\pi M_s^2$ is energy of demagnetizing field. For example, when the readout layer has the temperature dependency of M_s and K_u as shown in Fig. 8, the in-plane magnetization film appears at room temperature, since

$$K_u < 2\pi M_s^2 \text{ and } K_{\perp} < 0.$$

At information reproduction, however, M_s of the readout layer decreases since the temperature increases. Thus, $2\pi M_s^2$ rapidly decreases and the inequality relation between $2\pi M_s^2$ and the perpendicular magnetic anisotropy constant K_u is inverted. As a result, $K_u > 2\pi M_s^2$, $K_{\perp} > 0$

and the readout layer becomes a perpendicular magnetization film.

When the temperature is further raised and is over compensation temperature, the inequality relation between $2\pi M_s^2$ and perpendicular magnetic anisotropy constant K_u is again inverted. As a result, once more,

$$K_u < 2\pi M_s^2, K_{\perp} < 0$$

and the readout layer becomes a in-plane magnetization film.

In other words, the saturation magnetization M_s and the perpendicular magnetic anisotropy constant K_u of the readout layer are set so that the magnetization of the readout layer is an in-plane magnetization film (which functions as a mask) in the highest-temperature and low-temperature (nearly room temperature) points within the light spot and is a perpendicular magnetization film ((which functions as a detection area (aperture)) in an intermediate-temperature portion thereof, as shown in Fig. 4, considering the intensity and linear velocity of the laser light at the information reproduction. By setting such conditions in this way, only the highest-temperature and low-temperature points within the laser beam spot become an in-plane magnetization film. The other portion (the intermediate-temperature portion between high-temperature portion and low-temperature portion), however, is a perpendicular magnetization film.

Since the readout layer, which is a perpendicular magnetization film, is magnetically coupled to the recording layer due to exchange-coupling, the magnetization direction in the readout layer is aligned along a stable direction with respect to the magnetization direction based on the information recorded on the recording layer. In other words, information recorded on the recording layer is transferred to the readout layer. The transferred information is converted to an optical signal by magneto-optical effect (more specifically, magneto-optical effect of a laser beam reflected from the readout layer) and is detected thereafter. In this case, no magneto-optical effect occurs in a portion within the laser beam spot where the readout layer is an in-plane magnetization film.

Further, above-mentioned embodiment is described as a case of magnetic coupling due to exchange coupling between the readout layer and the recording layer, but the recording and readout layers may be magnetically coupled to each other at the time of reproduction due to magnetostatic coupling. When the readout layer and the recording layer are layered directly or with an intermediate layer therebetween, the temperature region of a perpendicular magnetization shifts toward a lower value in comparison with a case where the readout layer and the recording layer are not layered, since exchange coupling force, magnetostatic coupling force or the like acts from the perpendicular magnetization film and thus K_u increases in appearance. However, by presetting the perpendicular magnetization temperature range, in a single layer structure, at a slightly higher value, it is possible that the readout layer is an in-plane magnetization film at both room temperature and higher temperatures, and is changed to a perpendicular magnetization film only at the intermediate temperatures therebetween even when the readout layer is layered along with the perpendicular magnetization layer.

Moreover, masking may be achieved at the highest-temperature point or region by disappearance of magnetization in the readout layer. However, signal level in reproducing might be slightly reduced since Curie temperature T_c of the readout layer needs to be lower than T_c of the recording layer.

The following is an example of an improved magneto-optical recording medium which contains an intermediate layer between a readout layer and a recording layer as shown in Fig. 2.

In this example, an intermediate layer is interposed between a

readout layer and a recording layer. Curie temperature of the intermediate layer is higher than room temperature and lower than those of the readout and recording layers. Material for the intermediate layer may be, for example, rare-earth and iron group amorphous alloy, such as TbFe, GdFe, TbFeCo and GdFeCo, or these alloys to which non-magnetic elements such as Al, Cu, Cr, etc. are added.

Meanwhile, in a portion where temperature increases due to projection of a readout laser beam, the readout layer is changed from an in-plane magnetization film to a perpendicular magnetization film, similar to the above-mentioned example. The intermediate layer can function as a mediator of exchange-coupling force from the recording layer to the readout layer until its Curie temperature is reached, and information in the recording layer is transferred to the readout layer.

However, the exchange-coupling between the readout and recording layers is interrupted at a high-temperature portion of the intermediate layer where its Curie temperature has been reached. In the portion, the perpendicular magnetic anisotropy constant of the readout layer rapidly decreases in appearance due to such loss of exchange-coupling force from the recording layer. Therefore, the magnetization direction of the readout layer becomes an in-plane direction again (see Fig. 6)

Thus, in such a case where the intermediate layer, which has a low Curie temperature, is formed, the readout layer can be an in-plane magnetization film at both of room temperature and higher temperatures and can be a perpendicular magnetization film at the intermediate temperature therebetween, in its layered structure together with the intermediate and recording layers, without using the readout layer which can return again, in its single layer state, to an in-plane

magnetization film at higher temperatures. Thus, the recording medium has the advantage that material can be selected from a wider range.

As mentioned above, the information reproducing method, which uses the magneto-optical recording medium according to the present invention, enables to reproduce information with high resolution even when the information is recorded in higher density, since a reproducing portion within the laser beam spot is located in a narrow zone between a high-temperature portion and a low-temperature portion, as shown in Fig. 4.

Further, it is expectative that still better C/N ratio can be attained because the detecting region is placed in a center of the laser beam spot.

The reason is that a position closer to the center of the spot is better for reproducing information in larger C/N ratio since intensity of the laser beam is a Gaussian type and the intensity at a center of the laser spot is highest. (Generally, the center of the spot is not coincident with the center of temperature distribution of the recording medium when the medium moves. The highest temperature point shifts toward the moving direction of the medium. Therefore, when the highest-temperature point is selected as a detectable area, the detecting area will be deviated from the center of the spot (see Fig. 5))

Experimental examples of the present invention will be described hereinafter. They are illustrative and not restrictive within the scope of the present invention.

[First experimental example]

Targets of Si, Tb, Gd, Fe, Co and Al are installed in a DC magnetron sputtering equipment, and a glass substrate is held on a holder. Thereafter, air is vacuum-exhausted from a chamber to establish a high vacuum level of less than 1×10^{-5} Pa by using a cryosorption pump.

Ar gas is introduced into the chamber until the level of 0.3 Pa of Ar gas is reached, while vacuum-exhausting air. Thereafter, a SiN layer is deposited to a thickness of 700 Å as an interference layer; a GdFeCo layer is deposited to a thickness of 400 Å as a readout layer; a TbFeCo layer is deposited to a thickness of 400 Å as a recording layer; and then another SiN layer is deposited to a thickness of 800 Å as a protective film; and then, a layered film, which has the structure as shown in Fig. 3 (a), is attained.

When the SiN layer is formed, N₂ gas is introduced in addition to the Ar gas and the deposition is performed by DC reactive sputtering.

The GdFeCo and TbFeCo layers are formed by utilizing spontaneous sputtering, while applying DC power to targets of Gd, Fe, Co and Tb, respectively.

The composition of the GdFeCo layer is set so that its compensation and Curie temperatures are 270°C and over 400°C, respectively.

The composition of the TbFeCo layer is adjusted so that its compensation and Curie temperatures are less than room temperature and 230°C, respectively.

It has been found that Kerr effect (residual Kerr rotation angle), when no magnetic field is applied, appears only in a range from 130°C to 180°C and a perpendicular magnetization film is established as shown in Fig. 10, by measuring the residual θ_K when magnetic field is

zero while the temperature of the layered films is raised.

[Second experimental example]

Next, a magneto-optical recording medium is fabricated which has the same layer structure as that of the above-mentioned experimental example. A polycarbonate substrate having a diameter of 130 mm with pregrooves is installed.

Then, recording-reproducing characteristics of this magneto-optical recording medium are measured.

A measuring instrument comprises an objective of 0.55 N.A. and a projector for outputting a laser beam of 780 nm wavelength. Power for recording is preset at 8 mW and linear velocity is 9 m/sec. Then, 2-10 MHz carrier signal is recorded on the recording layer with intervals of 2 MHz as an interference layer by using a field modulation system. The record-frequency dependency of C/N ratio is measured. The result of measuring is shown in Table 1. The reproducing power is set so that C/N ratio is maximized. Record magnetic field is ± 500 Oe.

[Third experimental example]

Targets of Si, Tb, Gd, Fe, Co and Al are installed in a DC magnetron sputtering equipment, and a polycarbonate substrate is held on a holder. Thereafter, air is vacuum-exhausted from a chamber to establish a high vacuum level of less than 1×10^{-5} Pa by using a cryosorption pump. Ar gas is introduced into the chamber until the level of 0.3 Pa of Ar gas is reached, while vacuum-exhausting air.

Thereafter, a SiN layer is deposited to a thickness of 830 Å as an interference layer; a GdFeCo layer is deposited to a thickness of 400 Å as a readout layer; a TbFeCoAl layer is deposited to a thickness of 100 Å as an intermediate layer; a TbFeCo layer is deposited to a thickness of 300 Å as a recording layer; and then another SiN layer is deposited to a thickness of 700 Å as a protective film; and thus, a magneto-optical recording medium as shown in Fig. 3 (b) is fabricated.

When the SiN layer is formed, N₂ gas is introduced in addition to the Ar gas, and the deposition is performed by DC reactive sputtering. The GdFeCo and TbFeCo layers are formed by utilizing spontaneous sputtering, while applying DC power to targets of Gd, Fe, Co and Tb, respectively. The composition of those layers is adjusted by controlling applied DC power to the respective targets.

The GdFeCo readout layer is set so that its compensation and Curie temperatures are 250°C and over 310°C, respectively.

The TbFeCoAl intermediate layer is adjusted so that its Curie temperatures is 150°C.

The TbFeCo recording layer is adjusted so that its Curie temperature is 210°C.

A measuring instrument comprises an objective of 0.55N.A. and a projector for outputting a laser beam of 780 nm wavelength. Power for recording is preset at 8.2 mW and linear velocity is 9 m/sec. Then, 6-14 MHz carrier signal is recorded in the recording layer with intervals of 2 MHz by using a field modulation system. The record-frequency dependency of C/N ratio is measured. Record magnetic field is ± 300 Oe. The result of measurement is shown in Table 1.

Similarly, 4th to 9th experimental examples are shown in Table

1.

[Comparative experimental example]

Conditions of this comparative experimental example of a magneto-optical recording medium are the same as the first experimental example except that compensation and Curie temperatures of the readout layer are 280°C and 300°C, respectively. The layered layers have the temperature dependency of residual θ_K as shown Fig. 11. Then, the deposition is performed on the polycarbonate substrate, similar to the second experimental example. After the magneto-optical recording medium is thus fabricated, the record-frequency dependency of C/N ratio has been similarly inspected. The result is shown in Table 1.

Table 1

	readout layer		intermediate layer		recording layer		C/N (dB)		
							mark length		
	comp.	thick. (Å)	comp.	thick. (Å)	comp.	thick. (Å)	0.3 μm	0.4 μm	0.5 μm
example 1, 2	GdFeCo 400		non		TbFeCo 400		33	43	48
example 3	GdFeCo 400		TbFeCoAl 100		TbFeCo 300		32	41	44
example 4	GdFeCo 350		non		TbFeCo 370		30	42	45
example 5	GdTbCo 300		non		TbFeCo 400		30	41	44
example 6	GdFeCo 400		non		DyFeCo 380		32	40	44
example 7	NdGdFeCo 370		non		TbFeCo 400		30	42	46
example 8	GdFeCo 400		TbFeCoCu 50		TbFeCo 450		32	42	45
example 9	GdFeCo 360		GdFeCo 80		TbFeCo 300		35	44	48
com. ex.	GdFeCo 400		non		TbFeCo 400		24	37	42

Advantages of The Present Invention

Using reproducing methods according to the present invention enable a simply configured apparatus having no magnet for initialization (a prior apparatus) to read out a magnetic domain less than the diameter of a laser beam spot and achieve high density recording whose linear recording density is further improved.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic view illustrating a magnetized situation of a magneto-optical recording medium of the present invention.

Fig. 2 is a schematic view illustrating another magnetized situation of the magneto-optical recording medium.

Fig. 3A is a schematic view showing the layer structure of the magneto-optical recording medium shown in Fig. 1.

Fig. 3B is a schematic view showing the layer structure of the magneto-optical recording medium shown in Fig. 2.

Fig. 4 is a view explaining an information reproducing method by using the magneto-optical recording medium shown in Fig. 1.

Fig. 5 is a view explaining an information reproducing method by using the magneto-optical recording medium different from that of the present invention.

Fig. 6 is a view explaining an information reproducing method by using the magneto-optical recording medium shown in Fig. 2.

Fig. 7 is a view illustrating the relation between the beam intensity of a light spot and detection region within the light spot.

Fig. 8 is a graph illustrating an example of the temperature dependencies of $2Ms'$ and the perpendicular magnetic anisotropy constant K_u of a readout layer of the magneto-optical recording medium according to the present invention.

Fig. 9 is a graph illustrating an example of the temperature dependency of a residual θ_K (when a magnetic field = 0) of the magneto-optical recording medium according to the present invention.

Fig. 10 is a graph illustrating an example of the temperature dependency of a residual θ_K (when a magnetic field = 0) of a magneto-optical recording medium according to an comparative experimental example.

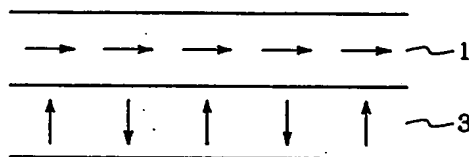
【書類名】

図面

Name of Document Drawings

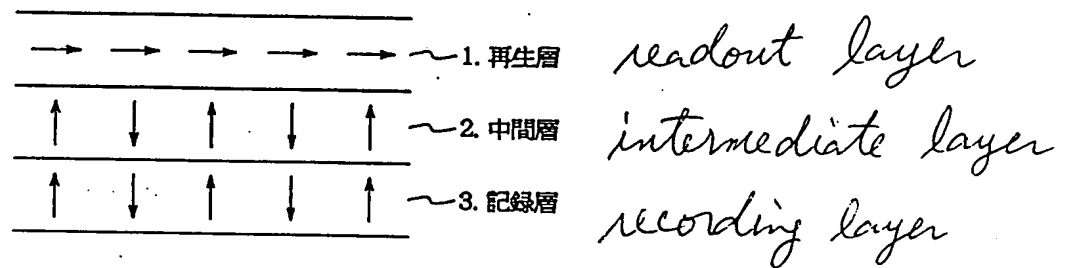
【図 1】

Fig. 1



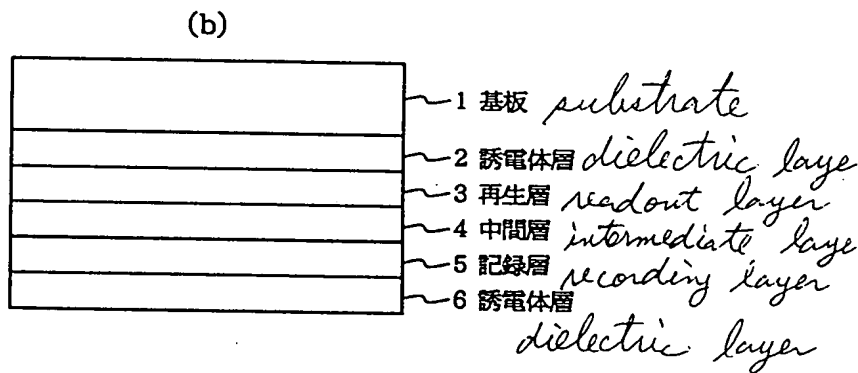
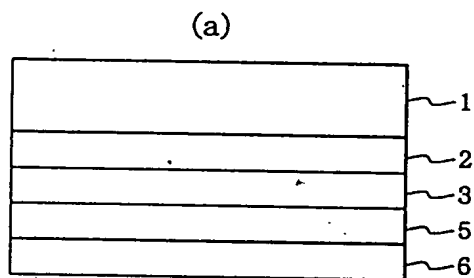
【図 2】

Fig. 2



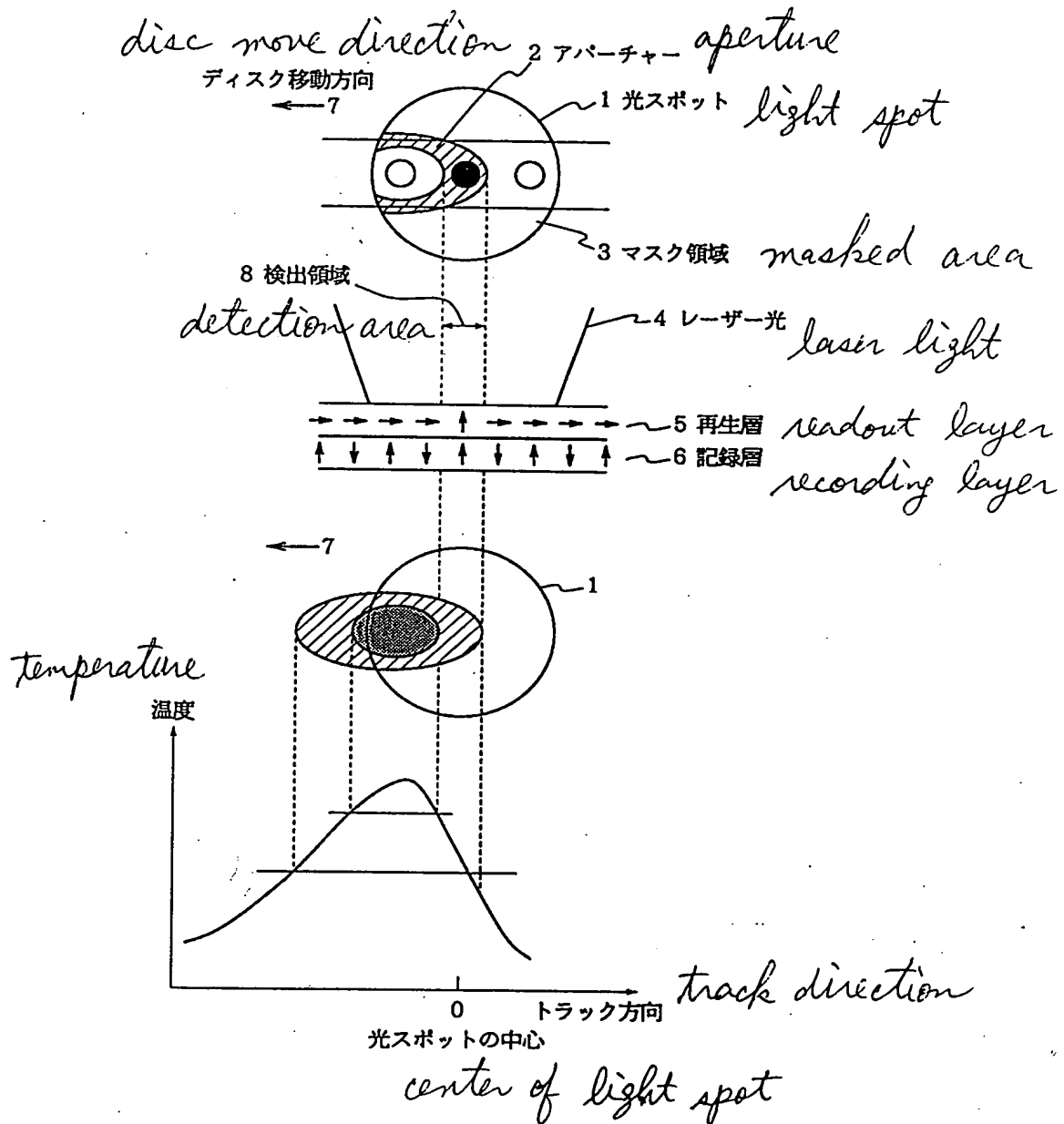
【図 3】

Fig. 3



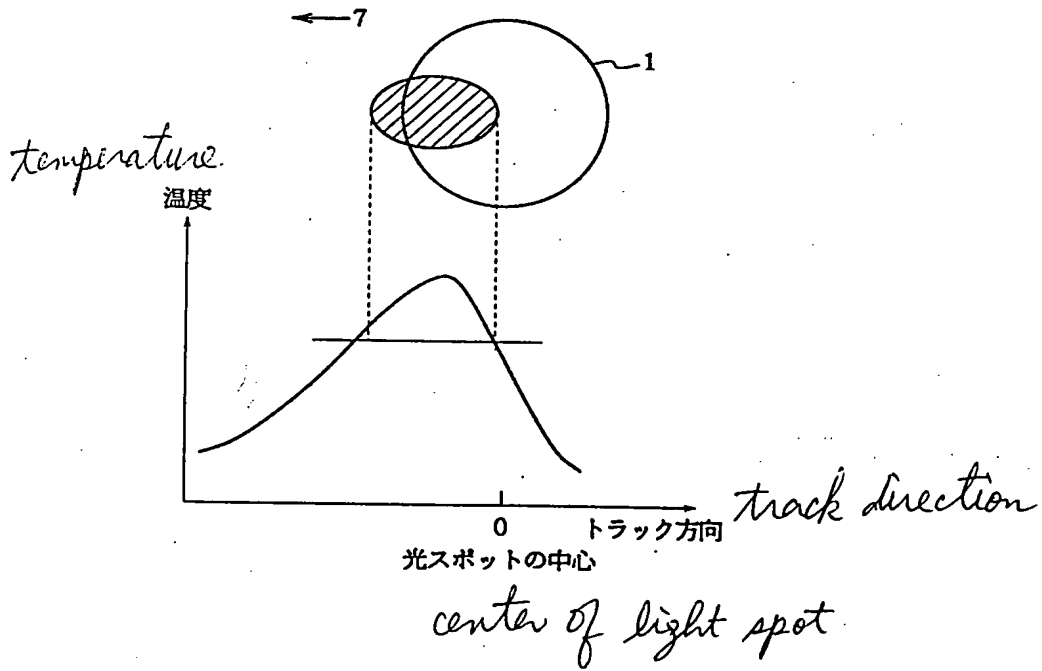
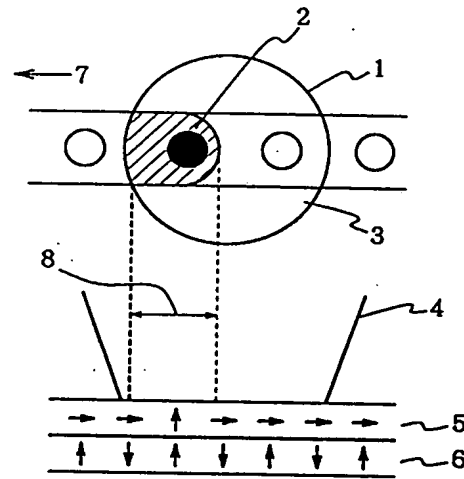
【図 4】

Fig. 4

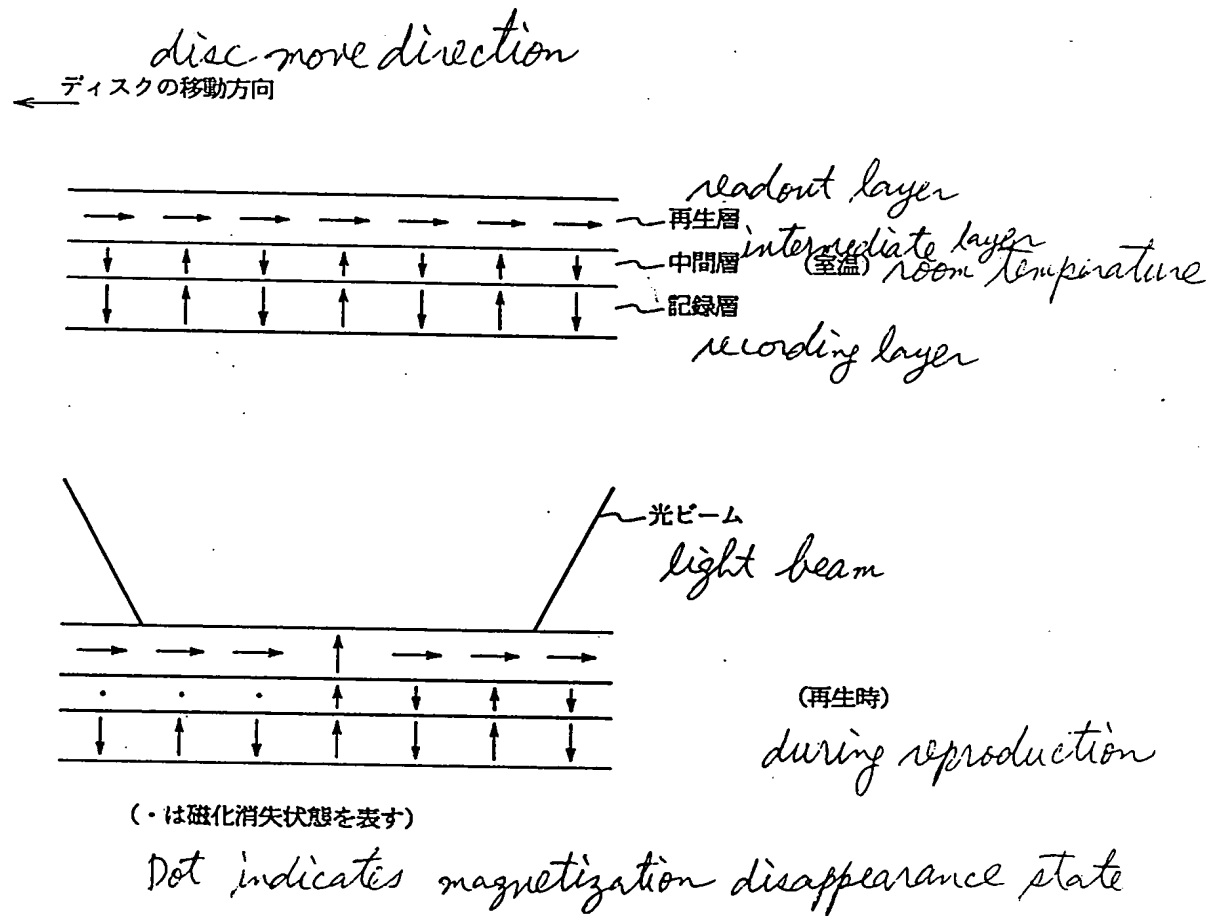


【図 5】

Fig. 5

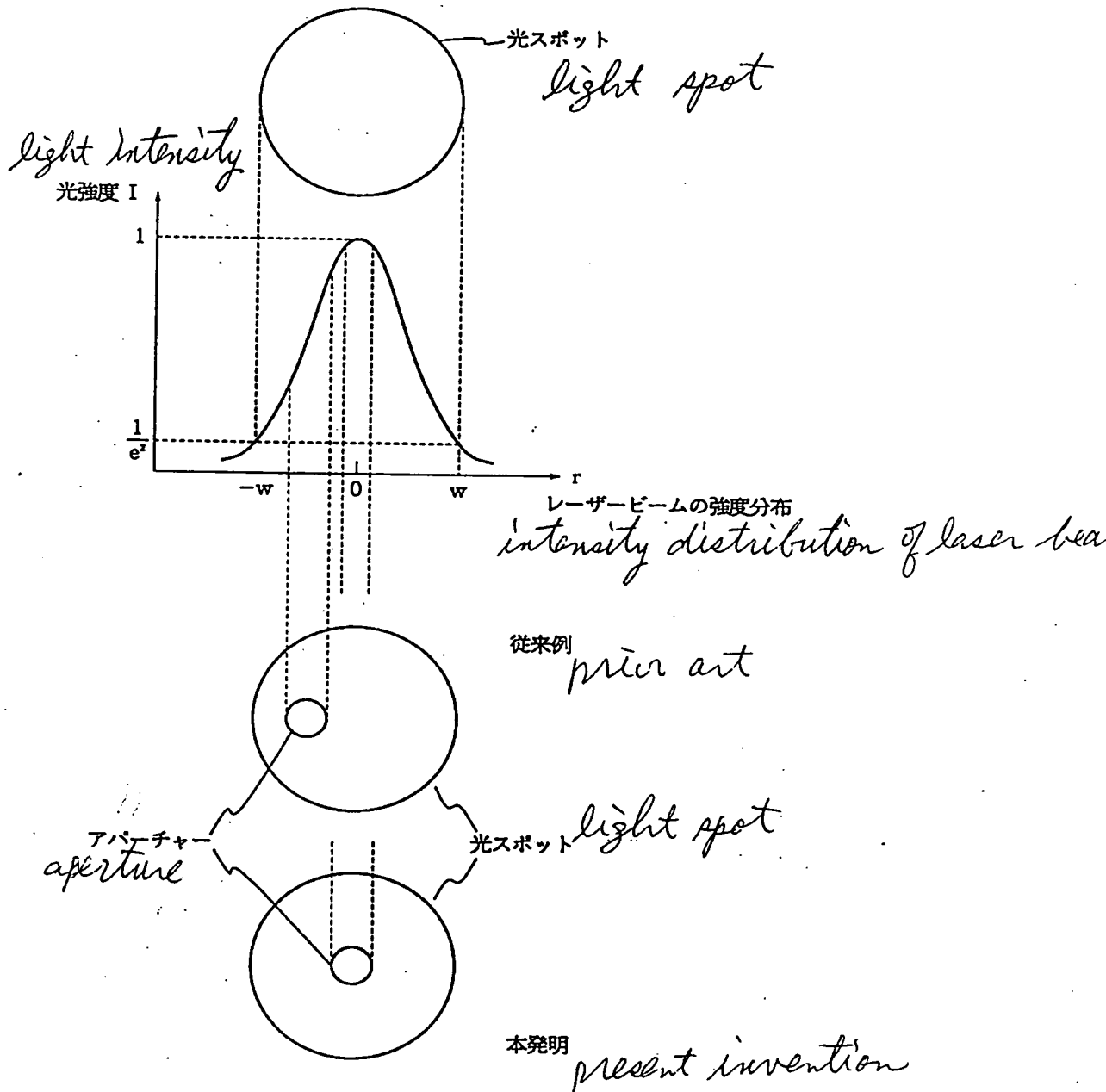


【図6】



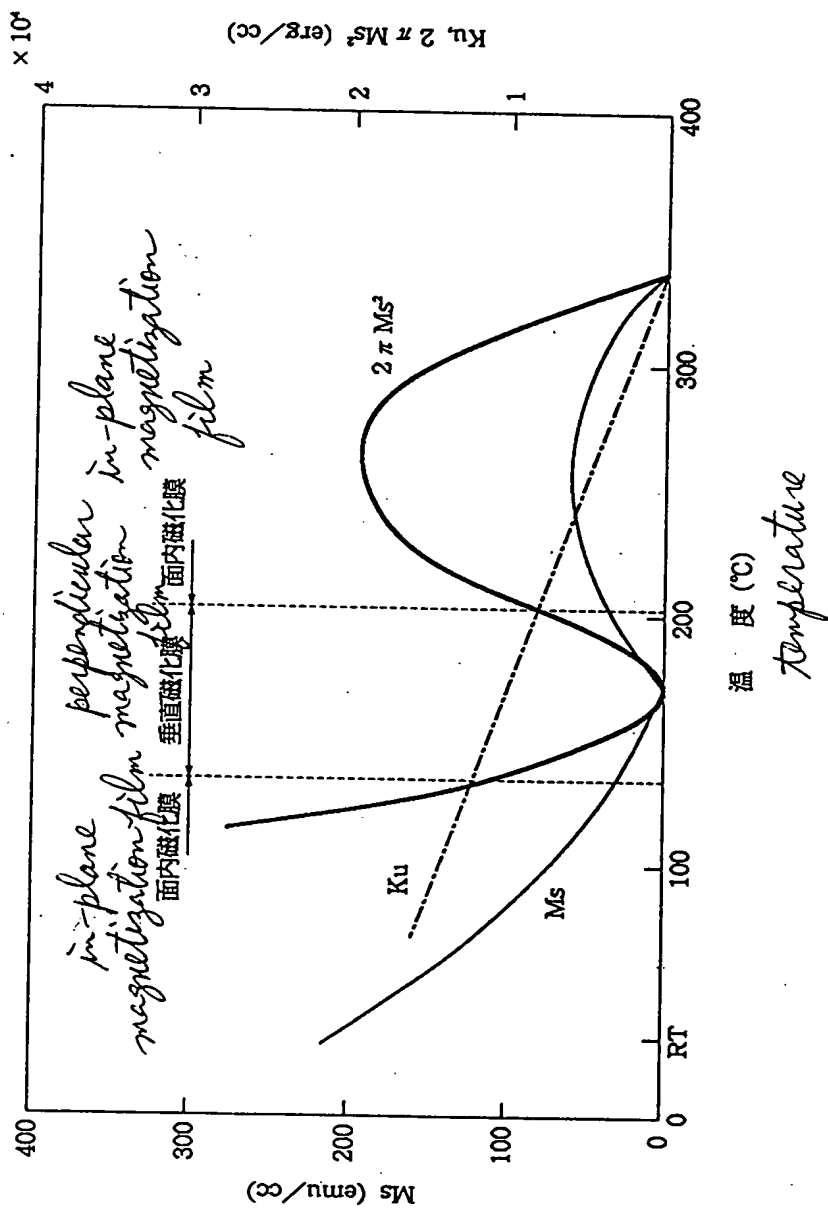
【図 7】

Fig. 7



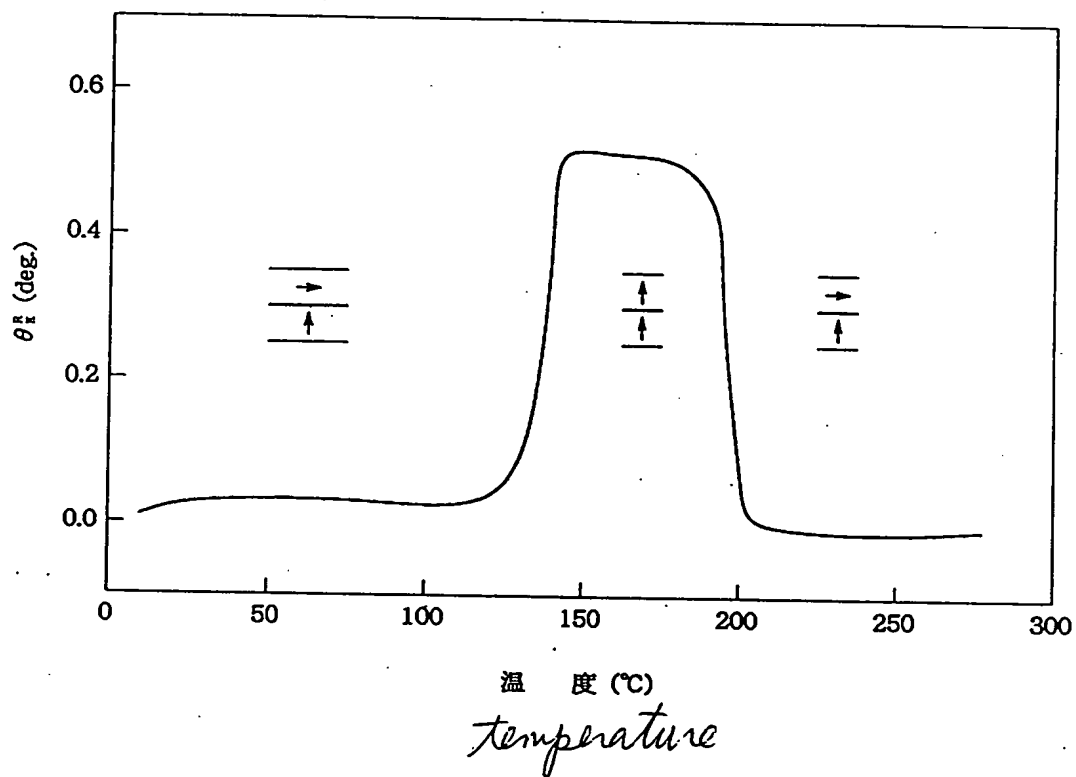
【図 8】

Fig. 8



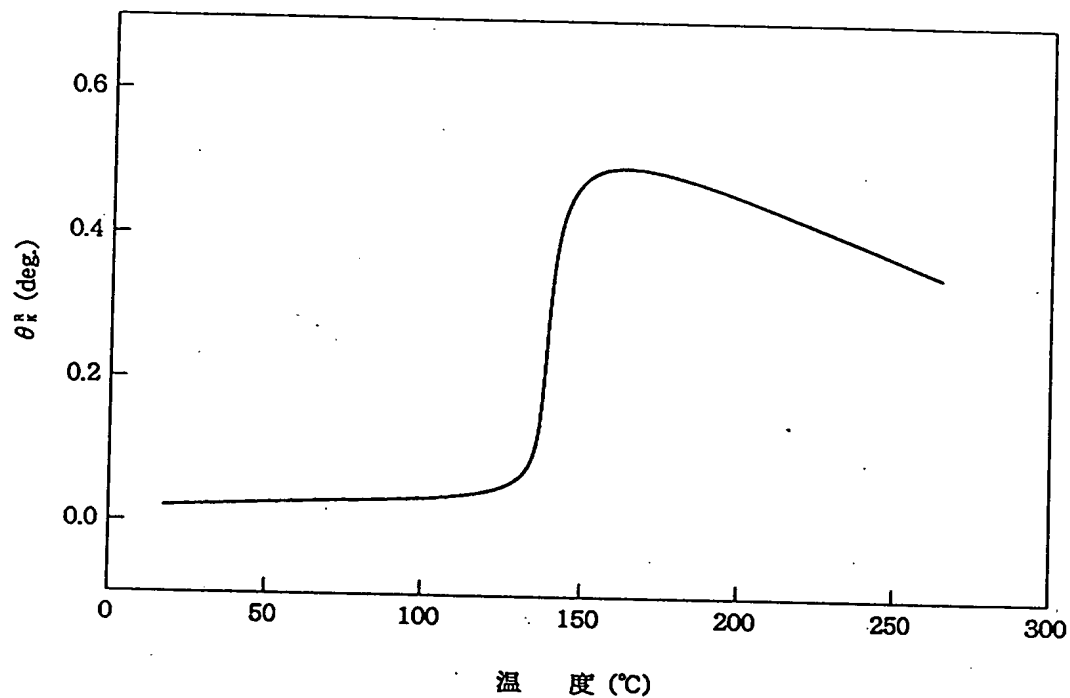
【図 9】

Fig-9



【図 10】

Fig. 10



temperature

NAME OF DOCUMENT

Abstract

SUMMARY

OBJECT

It is an object of the present invention to provide a magneto-optical recording medium in which it is able to reproduce a signal, whose periodicity is below the limit of light diffraction, by simple configuration, and information reproducing methods using the medium.

CONSTITUTION

An information reproducing method uses a magneto-optical recording medium which comprises a first magnetic layer being a perpendicular magnetization film at room temperature and changed to an in-plane magnetization film at raised temperatures, and a second magnetic layer composed of a perpendicular magnetization film. The method comprises a step of changing said first magnetic layer to a perpendicular magnetization film, in a region within a light spot projection portion, by projecting a light spot onto said first magnetic layer, a step of aligning a magnetization direction of said region in a stable direction with respect to a magnetization direction based upon information recorded on said second magnetic layer, and a step of reproducing said information by utilizing magneto-optic effect of reflective light of said light spot.

SELECTED FIGURE

Figure 4